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VEGETATION STUDIES IN NORTH-WEST VICTORIA
I. THE BEULAH-HOPETOUN AREA

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Summary

The soil and vegetation interrelationships of an area of the Mallee Region of Victoria are discussed, and the original vegetation formations of the area reconstructed and mapped from remnants preserved along road reserves. Two distinct sub-formations are present: the *E. largiflorens* savannah woodland association which is restricted to the heavy clay soils of the flood plain of the Yarriambiac Ck, and a mixture of mallee scrub associations which dominate a complex of lighter soils of the rest of the area. The distribution of the various mallee eucalypts was analysed using positive interspecific correlation.

Introduction

The area studied comprises the parishes of Kallery, Carori, Goyura, and parts of the parishes of Gutchu, Byanga, and Galaquil. It covers approximately 200 square miles and is situated between the towns of Beulah and Hopetoun which lie on the Henty Highway approximately 250 miles NW. of Melbourne (Fig. 1).

Although the vegetation of the region is predominantly characterized by members of the multi-stemmed group of the genus *Eucalyptus* known as 'mallees', it is linked with grassland and savannah woodland communities to the south, by the species characteristic of the flood plain of the Yarriambiac Ck. The soils, too, show transitional properties, so that the area is appropriately referred to as 'Mallee Fringe' country. The boundary of the Murray Mallee Region passes through the area (Hills 1939).

There has been little previous work on soils and vegetation in the Victorian Mallee Region. Zimmer (1937) dealt only in very general terms with the country to the north. Newell (1961) described the soils of the Mallee Research Station, Walpeup, and included sparse notes on the vegetation. Rowan and Downes (1963) studied the whole of NW. Victoria; they used the land unit approach to describe the soils and their land use characteristics.

Physiography and Geology

NNW.-SSE. Ridges

The principal physiographic features are broadly undulating NNW.-SSE. ridges approximately 2 miles wide and spaced about the same distance apart. The most conspicuous of these are the two which govern the course of the Yarriambiac Ck, an effluent of the Wimmera R., through the area studied. These two ridges arise at Jung, 60 miles to the south, and continue N. to Hopetoun. Other less conspicuous ridges can also be located, although in the country farther north they are obscured by the E.-W. dune component.

Hills (1939) considered these ridges to represent faulting and warping in the buried bedrock upon which the Cainozoic rocks of the Mallee Region rest. This view has not been supported by later workers; Blackburn (1962) believed them to represent stranded coastal dunes of the receding Miocene Murray Gulf. In the

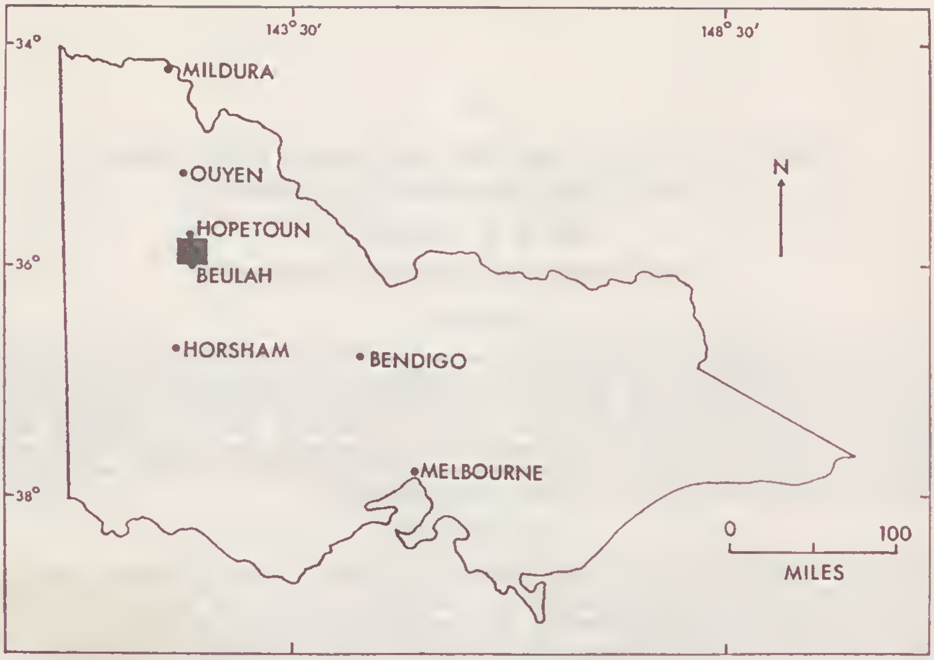

Fig. 1—Location of the area.

Beulah Area much of these NNW. ridges has been overlain by Recent sands of an E.-W. dune system. Wherever the E.-W. dune system is absent from the ridge surface, ironstone gravel can be found exposed, indicating perhaps a fossil soil formation and certainly an older land surface. At present, we can only speculate on the age of these structures; as a buried topography they could be of Pliocene age (cf. Northcote (1951) at Coomealla, New South Wales); as stranded dunes they might be Pleistocene. Sprigg (1952) suggested that the beginning of the Pleistocene corresponded with the eastern series of inland stranded coastal dunes which are associated with the Kanawinka fault running through Naracoorte, South Australia. However, no reliable dating is available and the Plio-Pleistocene boundary remains indefinite (E. D. Gill pers. comm.).

Inter-Ridge Valleys

The valleys between the NNW.-SSE. ridges are based upon estuarine and fluviatile silts and clays deposited by the drainage system of the newly elevated Pliocene Murray Gulf. These deposits are covered to varying extents, or have their surface layers contaminated with accessions of sandy material from the NNW.-SSE. ridges, E.-W. dunes (see below), and by regional dust (parna) carried in by the prevailing winds. Although this must have been the condition 80 years ago before settlement, it is difficult to tell how much of the intermingling of ridges and valleys, so noticeable at the present time, has resulted directly from the large scale clearing that commenced around 1880.

Yarriambiac Creek

The Yarriambiac Ck and its floodplain have characteristic soils and vegetation and, together, are appropriately considered as a distinct physiographic unit.

E.-W. Dunes

Recent sands have encroached westwards on to the area from stranded coastal dunes (Crocker 1946) and from previous courses of the R. Murray (Sprigg 1959). These have been shaped under the influence of the prevailing winds, by a combination of wind channelling and sand shepherding, to form parallel dunes. The dominant winds in the Victorian Mallee Region are westerlies so the resultant dunes trend E.-W. On the broader, Australia-wide scale, these dunes fit into the anticyclonic pattern suggested by King (1960).

In the very recent past, calcareous loess has been deposited over the whole area by wind winnowing and sifting of calcareous coastal dunes in South Australia (Crocker 1946). This has led to limestone horizons either as hard bands or soft or hard rubble in many soil profiles. That soil formation has been intermittent can be seen in the series of limestone bands in some profiles (Hills 1939). Drifting non-calcareous sand hills in virgin scrub show that soil formation is only poorly developed in adjacent areas. It is likely (Crocker 1946) that primary colonization of these aeolian materials began as recently as 4,000 years ago.

Lunettes

Attention was first drawn to these special landforms in the Echuca district and in the parish of Benjeroop, Victoria, by Harris (1939). Hills (1940) proposed a theory for their genesis and named them lunettes. Stephens & Crocker (1946) showed later that the theory of loessial accession suggested by Hills is not generally applicable. The lunettes are formed, as Harris originally pointed out, from material derived from the floors of the adjacent, associated depressions during periods in which they are dry. The loessial contributions suggested by Hills are intermittent and of only minor importance.

Two large lunettes are found in the area and their outlines are shown on the map (Fig. 4) adjacent to the E. margin of the creek flood plain. In addition, a number of smaller, less obvious but similar structures are found throughout the area. Because of the greater influence of sand drift in the Mallee Region, there is an appreciable percentage of saltation material in the lunettes in contrast to the more clayey formations of the Wimmera Region.

The water surfaces once associated with these lunettes have now subsided. They were previously linked with the now dwindling floodplain of the Yarriambiac Ck.

Climate

Meteorological data for the region are scarce, although a good synopsis of available information has been prepared by the Commonwealth Meteorological Bureau and published in Resources Survey—Mallee Region (Anon. 1952). A summary of the data for Beulah is made in Fig. 2. Rainfall varies from 14·3" per annum in the south to 13·2" per annum 20 miles to the north. Rosebery, with an annual rainfall of only 12·4", is anomalous, for it lies S. of Hopetoun and presumably nearer the 14" annual isohyet. Although rainfall is certainly of high winter-spring incidence, 40% of the rainfall falls in the summer and autumn months outside the growing season of cereal crops.

The average frost-free period (36°F +) is 232 days.

Drainage

No streams arise in the area but the Yarriambiac Ck, an effluent of the Wimmera R. at Longeronong, has its northward course through the study area.

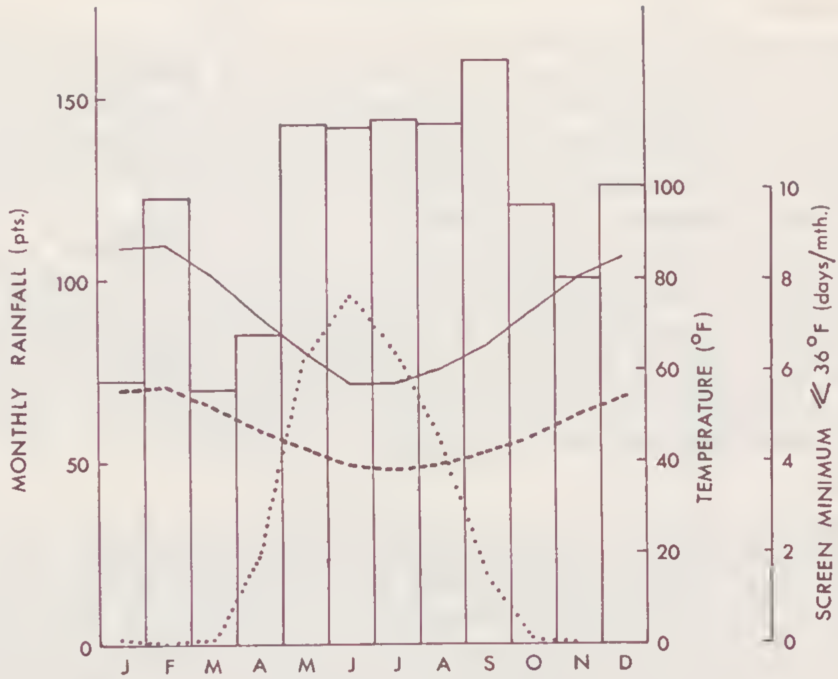

FIG. 2—A summary of climatic data for Beulah. Histogram of monthly rainfall. Mean monthly maximum (——) and mean monthly minimum (-----) temperatures, and the monthly frequency of screen temperatures equal to or less than 36°F (···).

Water rarely reaches beyond Warraeknabeal (22 milcs S. of Beulah), although in 1956, which was an exceptionally wct year throughout the Statc, watcr reached as far north as L. Coorong where it floodcd ccreal crops sown on the dried-out lake bed. L. Coorong is situated ½ mile SE. of Hopetoun and is the depression in whieh the Yarriambiac Ck terminates.

Soils

A eonsideration of geologieal history and physiographic devclopment suggests a pedogenic pattern as shown by Fig. 3. This pattern is borne out by field observation within the area. The three types of parent material, indicated in the eentre of the diagrammatic representation, have varied with time depcnding upon a great number of faetors, many of which were operative in neighbouring physiographic zones. Groups B, D, and F cover a whole range of soil types in whieh the contribution of each parent material varies widely. An important eonsideration is that, sinee alluvial material predates saltation material and parna, the soils in Group F can show the morphological feature of a sudden transition to a clay subsoil. The surface layers represent later aeeumulations of lighter wind-borne material. The transition is not a result of pedogenic proeesses acting on a given parent material, as for example, in the formation of a red-brown earth.

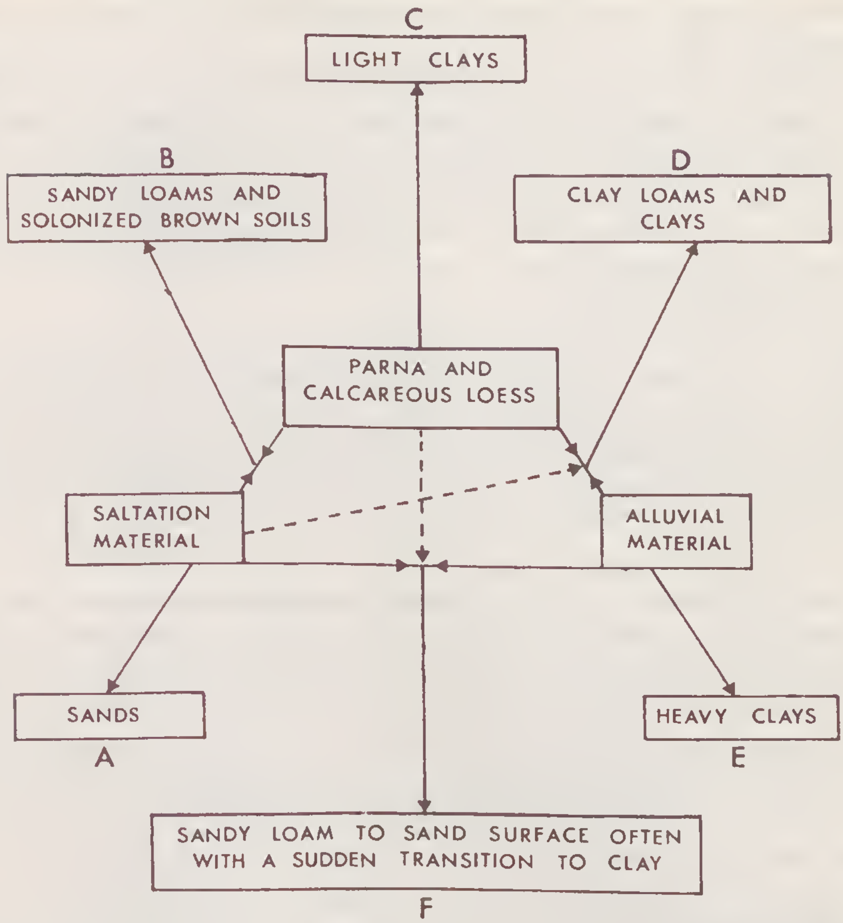

FIG. 3—Relationship between Parent Materials and Soils in the Beulah-Hopetoun area.

Despite the variability and intergradation of soil types, it is convenient to deal with the soils of the area in three broad groups related to the physiographic divisions of ridge and dune, valley, and creek flood-plain.

Representative profiles are described in Appendix 1, although with such a wide variation in soil characteristics they do not go very far in defining the soil system of the area. Much additional information on the soils can be obtained from Newell (1961), who has described similar soils in detail and indicated their variations for the Mallee Research Station, Walpeup, some 70 miles N. of the study area.

SANDY SOILS OF RIDGES AND DUNES: GROUPS A, B

The older sands of the NNW.-SSE. ridges are deep coloured, mostly in tones of red, whereas the later additions which form the E.-W. dunes are lighter and more yellow in colour. King (1960) speaks of 'white sands' as opposed to 'red sands'. At the present time the depth of loose sand is variable, but in general terms depth is greater on the dunes than on the ridges. This is not, however, invariably the case. Once again it is difficult to estimate the effects of the accelerated erosion of the past 80 years.

A limestone layer, which is an important feature of most soils in this grouping, is very variable both in type and in position. Not all soils have massive limestone in the profile, but most are highly calcareous. In some instances, erosion has exposed limestone rubble on the surface and upon this a further profile is developing.

No fertility differences are noticeable in the sandy soils. Crop growth is so dependent upon the moisture regime that major variations in yield can easily be attributed to either seasonal rainfall, pre-cropping treatment or both. Under the prevailing rainfall the water relations in these sandy soils are fair for cereals and good for deep rooted species.

Loams and Light Clays of the Inter-Ridge Valleys: Groups C, D

Surface texture and depth to subsoil vary considerably in these soils but can usually be related to the proximity of a sand source. Once again, the precaution is added that it is difficult to estimate the changes in the nature of the surface soil in the years following clearing. For the major part these soils have less than 6 in. of light material overlying the clay subsoil, although on roadsides it is possible to see up to 2 ft or even more of sandy accession collected against fences. Many fences in the area are lifted every few years; in other cases completely new fences have been erected over existing ones.

In the uncultivated state these soils show the gilgai micro-structure so common in the heavy soils of regions of sparse rainfall. In summer, when these soils dry out, they crack deeply and particles of the surface soil fall down the cracks adding to the bulk of the soil below. On rewetting, the clay minerals of the subsoil, when of the type that swell greatly, exert increased pressure which is relieved along lines of weakness to form the characteristic mounds on the surface. Since the alternative name 'crabhole' infers depression formation, the aboriginal name gilgai is preferred (Leeper 1957). Under repeated cultivation these minor surface fluctuations tend to be ironed out. In paddocks in which no gilgai formations are prominent it is possible to pick up their existence on 20-chains per inch aerial photomaps.

The clay soils have poor moisture relationships and consequently their usefulness for agriculture, even with the fallow technique, is largely governed by rain falling in the growing season.

Soils of the Creek Flood Plain: Group E

In some cases these soils correspond closely with those of the previous group, but in more typical locations they are equivalent to the grey and brown self-mulching, gilgai soils of the Wimmera plains such as have been described by Skene (1954, 1959), and in equivalent locations by Zimmer (1937), Beadle (1948), and Specht (1951).

In some places, which from aerial photography appear to be related to old courses of the Yarriambiac Ck, a soil with a red clay surface is found. Two profiles taken 20 yds apart on the same ground level describe the two contrasting soil types (Appendix 1, profiles 1a, 1b). It seems probable that these soils have formed on different parent materials and perhaps under different drainage conditions related in some way to previous courses of the Yarriambiac Ck.

Vegetation

The classification of the vegetation formations and the structural formulae applied to them follow Wood & Williams (1960). One alteration in their nomenclature, however, is considered necessary. This is to re-name their formation sclerophyll-shrub-woodland ($T/S_1S_2(d)$) as sclerophyll-scrub. The word woodland has been misused in this structural series, in which the spacing of the tallest stratum is dense (d). If this alteration is made, the Mallee, a multi-stemmed sub-form of the sclerophyll-scrub formation, is terminologically as well as structurally distinct from the woodland formation and, in particular, the sub-form savannah-woodland.

In the Beulah-Hopetoun area, only these two sub-forms, mallee and savannah-woodland, are present.

Savannah Woodland TG(m.d.)

The *Eucalyptus largiflorens** association is confined to the heavy textured, alkaline, gilgai soils (Group E) of the flood plain of the Yarriambiac Ck and to a few isolated patches of internal drainage among the mallee sub-formation in the inter-ridge valleys. The association has been described for equivalent habitats in New South Wales (Beadle 1948), South Australia (Specht 1951), and also in Victoria (Zimmer 1937). An occasional tree of *Casuarina leuhmannii* or *Myoporum platycarpum* is found with *E. largiflorens*. *Casuarina* forms extensive stands in the Wimmera but in this area it is restricted to the *E. largiflorens* association. *Myoporum*, a species common in more arid environments, occurs scattered throughout the area.

* The authorities for species names are contained in Appendix 2—Species Lists.

Mature trees of *E. largiflorens*, which may be up to 60 ft high, have a characteristic rounded crown with lower branches often drooping to the ground. It is difficult to be sure of the spacing of the trees in the natural condition except to say that they fit into the mid-dense (m.d.) classification of Wood & Williams (1960), i.e. spacing greater than twice the crown diameter.

The ground cover was probably originally dominated by the genera *Danthonia* and *Stipa* but is now largely replaced by a weed flora. Only occasional shrubs such as *Acacia oswaldii* and *Eremophila longifolia* are present. A list of species collected in this association is provided in Appendix 2.

Mallee T/S_1S_2(d.)

Members of this multi-stemmed group of the genus *Eucalyptus* comprise the dominant species of the most widespread vegetation sub-formation of the area. Height of the mallees varies from as low as 10 ft to as high as 40 ft in some cases. The tallest specimens are *E. behriana* growing in the wetter sites within its distribution. These specimens which are included in the structural formulae as T/S_1, are often single stemmed but present a gradation from this form to the mallee habit. Spacing of the eucalypts is dense, in many cases with touching canopies. Low shrubs (S_2), especially of the genus *Acacia*, are common. In the ground layer there is a noticeable contribution by the semi-succulent members of the family Chenopodiaceae which link the vegetation of this region with the more arid vegetation to the north. It is because of the presence of these plants that the term 'semi-arid mallee' has been applied to the drier end of the mallee sub-formation (Wood & Williams 1960).

A major part of the study of this area was concerned with analysing the distribution of the various mallee species. Traverses were made along all passable roads in the area, and at 0·3 mile intervals the dominant species and surface soil characteristics were recorded. Additional recordings were made at any opportunity. Since most of the area is cleared and under cultivation the only vegetation remaining is found along the roads. In most cases this is regrowth following 'rolling' or burning in the past. As the lignotuber present in mallee eucalypts enables the species to survive either of these methods of destruction, it is assumed that the natural distribution of these species has not been upset by the intervention of man. The texture of the surface soil at each site was noted at a suitable distance inside adjacent paddocks. This position was selected because the roadside vegetation and fences, which frequently show accumulations of wind-borne material from the adjacent farmlands, are much lighter in surface texture than they were under natural conditions. Within limits, surface soil texture indicates the position of any site in respect to ridge, dune or inter-ridge valley.

The most common mallee eucalypts in the area are: *E. oleosa, E. dumosa, E. calycogona, E. behriana.* Others present are *E. gracilis, E. viridis, E. incrassata* var. *costata*, and *E. foecunda.* From each of 503 sites which fell within the mallee sub-formation, the percentage of sites of each surface texture carrying each of these species was calculated. These data are presentd in Table 1.

TABLE 1

Distribution of the Major Mallee Eucalypts with Respect to Surface Soil Texture

(% of sites of a given textural class which contain each species)

Species	Surface Soil Texture					
	Loamy sand ls	Sandy loam sl	Sandy clay loam scl	Clay loam cl	Sandy clay sc	Clay c
E. behriana	4	33	50	76	98	100
E. dumosa	95	100	90	89	79	44
E. calycogona	41	61	57	54	17	0
E. oleosa	94	85	53	27	6	0
No. of sites in each textural group	155	100	90	96	53	9

The pattern which shows up so well in these data is not always obvious in the field; however, the large number of sites studied has enabled distribution to be analysed with confidence. *E. oleosa* shows a strong preference for the soils of the lightest surface soil texture class. The occurrence of this species quickly drops on soils with increasingly heavier surface soil texture. *E. behriana* on the other hand is found more frequently on the heavier surface soil texture types, but a noticeable feature is that it is more tolerant of lighter surface textures than is *E. oleosa* of the heavier surface textures.

The explanation of this lies in the surface soil texture distribution in the area. What is being shown is that *E. behriana* is limited almost entirely to soils of the valleys. Such soils have a range of surface soil textures from sandy loam to clay with an increasing incidence in the latter two classes. This is a result of erosive processes which have been stressed previously. On the other hand, *E. oleosa* is restricted to the soils of the ridges and dunes, which do not have a wide surface soil texture distribution, but which are largely of the two lightest classes. The spread of each species towards the other end of the surface texture scale is a measure of the mixing of the two species at the ecotonal boundaries.

The distribution of *E. calycogona* and *E. dumosa* show no striking relationship but appear to extend over the whole range of surface soil texture classes. The noticeable drop in the distribution of *E. dumosa* on the clay surface soil texture class shows up in x^2 tests in Table 2. *E. behriana* which is prominent on these soils is non-randomly distributed with *E. dumosa*. It is considered that this non-randomness is built up on these soils of heavy surface texture, and that *E. dumosa* does, as Table 1 illustrates, give way on these heavy surface soil types to *E. behriana* which then exists as a pure stand. The wide ecological range of *E. dumosa* can be partly answered by indicating that it really consists of a species complex. Although such a statement may be true of many species one would care to study, it is significant that a portion of the material included under the

TABLE 2

Association of dominant Mallee species

o *E. oleosa* c *E. calycogona*
b *E. behriana* d *E. dumosa*

i (χ^2 = 12.9)

c \ o	+	−
+	157	74
−	142	130

ii (χ^2 = 12.8)

d \ o	+	−
+	283	174
−	16	30

iii (χ^2 = 148.2)

b \ o	+	−
+	49	143
−	250	61

iv (χ^2 = 2.62)

d \ c	+	−
+	216	241
−	16	30

v (χ^2 = 4.34)

b \ c	+	−
+	89	129
−	143	142

vi (χ^2 = 14.18)

b \ d	+	−
+	186	32
−	271	14

Test		χ^2	Distribution	Probability
i	o x c	12.9	non random	< 0.01
ii	o x d	12.8	"	< 0.01
iii	o x b	148.2	"	<< 0.001
iv	c x d	2.62	random	> 0.05
v	c x b	4.34	"	> 0.05
vi	d x b	14.18	non random	< 0.01

name *E. dumosa* does in fact bear strong resemblance to the type specimen of *E. pileata* Blakely. Other material shows intermediary characters. A similar situation has recently been shown to exist on Eyre Peninsula, South Australia (Smith 1963).

Another way of expressing the distribution of the mallee eucalypts, which is independent of soil characteristics, involves the use of contingency tables (Goodall 1953). With the large number of sites available, it is possible to place a good deal of reliance on the outcome of these tests. Straightforward 2 × 2 presence and absence tables for pairs of species are the most useful, since higher order tables are generally difficult to interpret.

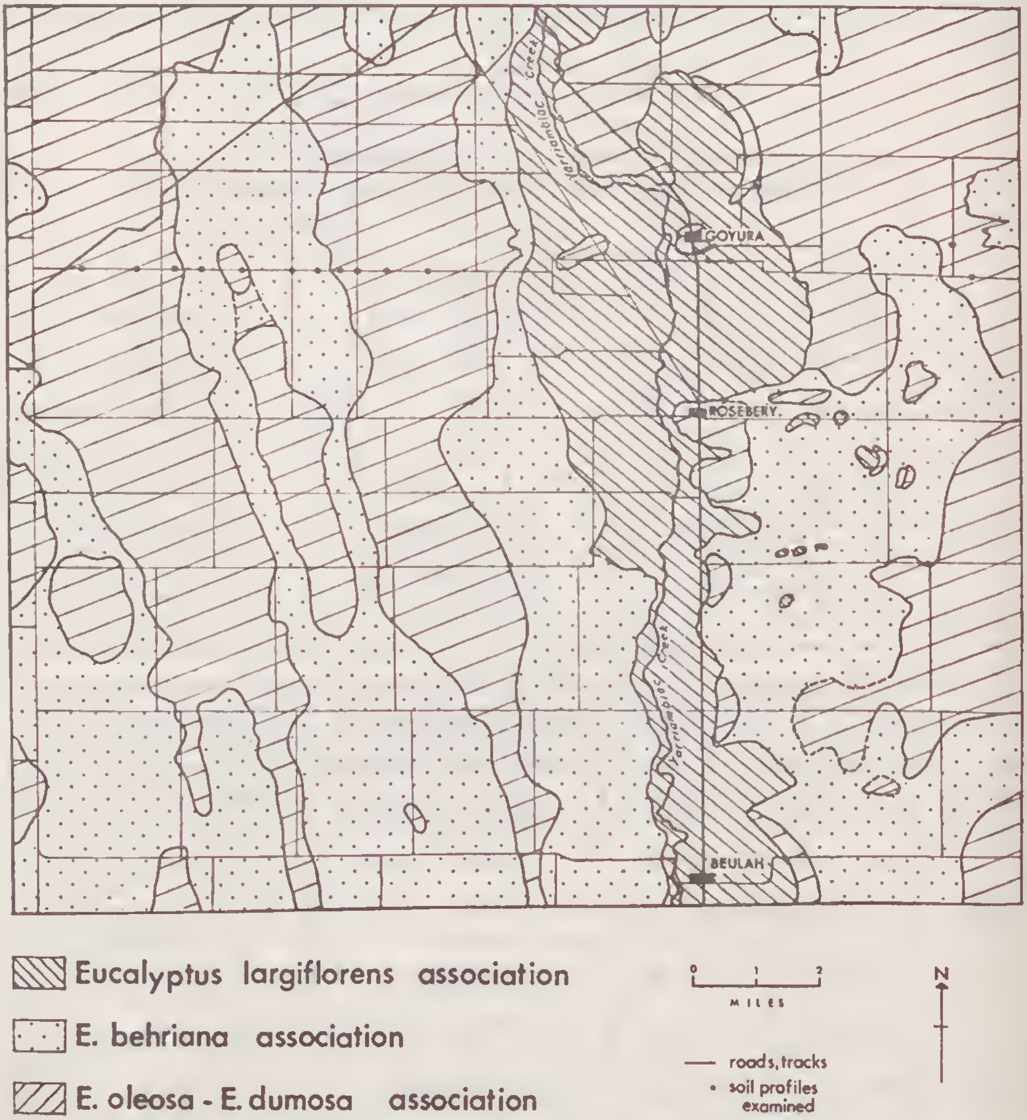

FIG. 4—Vegetation map for the Beulah-Hopetoun area.

Table 2 summarizes the results of x^2 tests carried out on the four major eucalypts. The most noticeable feature is the wide separation of *E. oleosa* (o) and *E. behriana* (b) which, using surface soil texture characteristics, occupy contrasting physiographic positions.

The distribution of *E. dumosa* follows that of *E. oleosa* but it is largely segregated from *E. behriana*. *E. calycogona* appears to occupy an intermediary position linking *E. oleosa* and *E. behriana*, which occupy the extreme physiographical and pedological positions in the area.

From the above observations the mallee sub-formation of this area has been divided into two parts, viz. the *E. behriana* association and the *E. oleosa-E. dumosa* association (Fig. 4). These correspond to valley and dune areas respectively.

Observations on the less common mallee species do not lend themselves to any statistical analysis. *E. incrassata* was found on six sites which were in the loamy sand surface texture class, and for three of these sites, at which soil cores were taken, the depth of sand exceeded the 54-in. range of the soil sampling tube. It would appear that *E. incrassata* is limited to those situations with the deepest surface sand layers—sites which are usually associated with the E.-W. dune component.

A species list for the component associations is presented in Appendix 2.

TABLE 3

Plant Associations of the Beulah–Hopetoun Area

Sub-Formation	Structural Formula	Community	Rainfall (in. per annum)	Soils
Savannah Woodland	TG (m.d.)	1. *E. largiflorens* association	14·3–12·4	Grey, brown soils of heavy texture associated with the flood plain of the Yarriambiac Ck
Mallee	T/S_1S_2 (d)	2. *E. behriana* association	14·3–12·4	Light clays of the inter-ridge valleys
	S_1S_2 (d)	3. *E. oleosa–E. dumosa* association	14·3–12·4	Solonized brown soils with sand up to 3 ft deep
	S_1S_2 (d)	4. *E. incrassata** association	13·2–12·4	Sandy soils with depth of sand > 4 ft, associated with the younger E.–W. dune system

* Rare in this area.

Discussion

In Table 3 the relationships between the structure and distribution of the vegetation associations present in the area are summarized. The distribution of these associations is recorded on a map of the area (Fig. 4).

Acknowledgements

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Mr J. H. Willis of the National Herbarium checked the identifications of the plant collection used in assembling Appendix 2. Miss J. Wood did the hand lettering on Fig. 4.

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Explanation of Plate

PLATE 58

Fig. a—*E. largiflorens* association, in this case with *Muehlenbeckia cunninghamii.*
Fig. b—*E. oleosa-E. dumosa* association.

Appendix 1

Representative Soil Profiles from the Beulah-Hopetoun Area

1. *Eucalyptus largiflorens* association (Savannah Woodland Sub-formation)
(1 mile S. of Goyura)

(a) 0-6″ grey (10YR5/1) (Munsell 1948) light clay breaking down to fine granular aggregates when dry. Fine calcium carbonate concretions.
6-12″ dark grey (10YR4/1) medium clay of blocky structure. Friable with slight soft calcium carbonate concretions.
12-48″ gradual transition to greyish brown (2·5Y5/2) medium clay high in calcium carbonate.
48″ continuing.

(b) 20 yds from (a)
0-6″ dark reddish brown (5YR3/4) medium clay forming a surface seal after rain.
6-12″ dark red (5YR3/6) medium clay with blocky structure.
12-48″ gradual transition to yellowish red (5YR4/6) medium clay high in calcium carbonate.
48″ continuing.

2. *Eucalytus behriana* association (Mallee Sub-formation)
(5 miles W. of Goyura)
0-3″ dull reddish brown (5YR4/4) sandy loam showing stratification, and having a clear boundary with
3-10″ dark reddish brown (5YR3/4) sandy clay loam increasing gradually in texture to
10-24″ reddish brown (5YR4/4) light clay with slight lime passing to
24-42″ yellowish-red (5YR4/6) medium clay with pale-brown mottling and moderate lime
42″ continuing.

3. *Eucalyptus oleosa-E. dumosa* association (Mallee Sub-formation)
(4 miles W. of Goyura)
0-5″ reddish brown (5YR4/4) sandy loam with slight fine soft lime.
5-20″ soft lime increasing with depth.
20-30″ dull reddish brown (5YR4/4) sandy loam with massive travertine layer.
30-39″ yellowish-red (5YR4/6) light sandy clay with medium lime and rubble.

4. *Eucalyptus oleosa-E. dumosa* association (Mallee Sub-formation)
(7 miles W. of Goyura)
0-3″ dull reddish brown (5YR4/4) sandy loam with organic matter
3-27″ dull reddish brown (5YR4/4) sandy loam sharp boundary with
27-33″ red sand (2·5YR4/6) grading into
33-39″ red sand (2·5YR4/6) with soft limestone rubble
39″ + heavy limestone rubble.

APPENDIX 2

A List of Plants Recorded Growing in the Component Associations

1. *Eucalyptus largiflorens* association
2. *E. oleosa–E. dumosa* association
3. *E. behriana* association

An asterisk before a species name indicates that the species is introduced.

	1	2	3
CUPRESSACEAE			
Callitris preissii Miq.	–	+	–
GRAMINEAE			
* *Ehrharta calycina* Sm.	–	+	–
Distichlis distichophylla (Labill.) Fasset	+	–	–
* *Lolium perenne* L.	+	–	+
* *L. rigidum* Gaudin	+	+	+
* *Bromis mollis* L.	+	–	+
* *B. diandrus* Roth	–	+	+
* *B. rubens* L.	+	+	+
* *Hordeum leporinum* Link	+	+	+
* *H. hystrix* Roth	+	+	+
* *Avena fatua* L.	+	+	+
* *Aira caryophyllea* L.	+	+	+
* *Phalaris minor* Retz.	+	–	–
Agrostis avenacca J. F. Gmel.	+	–	–
Chloris truncata R.Br.	+	–	–
Cynodon dactylon (L.) Pers.	+	–	–
* *Schismus barbatus* (L.) Thell.	–	+	–
Danthonia setacea R.Br.	+	+	–
D. caespitosa Gaudich.	+	–	+
Stipa platychaeta D. K. Hughes	–	+	+
S. aristiglumis F. Muell.	+	+	–
S. variabilis D. K. Hughes	+	+	+
S. nitida V. S. Summerhayes and C. E. Hubbard	–	+	–
S. drummondii Steud.	–	+	–
S. eremophila F. M. Reader	–	+	+
Panicum prolutum F. Muell.	–	–	+
* *P. milaceum* L.	–	+	–
CYPERACEAE			
* *Cyperus eragrostis* Lam.	+	–	–
Eleocharis acuta R.Br.	+	–	–
Carex inversa R.Br	+	–	–
JUNCACEAE			
Juncus pallidus R.Br.	+	–	–
J. filicaulis Buch.	+	–	–
LILIACEAE			
* *Asphodclus fistulosus* L.	–	+	–
Bulbine bulbosa (R.Br) Haw.	+	–	–
Dianclla revoluta R.Br.	–	+	+
CASUARINACEAE			
Casuarina luehmannii R. T. Baker	+	–	–
PROTEACEAE			
Hakea vittata R.Br.	–	+	–
LORANTHACEAE			
Amyema miquelii (Lehm.) Van Tiegh.	–	–	+
SANTALACEAE			
Santalum acuminatum (R.Br.) A.DC.	–	+	+

APPENDIX 2—*continued*

	1	2	3
POLYGONACEAE			
* *Polygonum aviculare* L.	+	+	−
* *P. bellardii* All.	−	+	−
Muehlenbeckia cunninghamii (Meissn.) F. Muell.	+	−	−
Rumex crystallinus Lange	+	−	−
* *R. acetosella* L.	+	−	+
CHENOPODIACEAE			
Rhagodia spinescens R.Br.	+	−	−
R. nutans R.Br.	+	+	+
Chenopodium album L.	+	+	+
C. pumilio R.Br.	+	+	+
Atriplex semibaccata R.Br.	+	+	+
A. muelleri Benth.	−	−	+
Bassia uniflora (R.Br.) F. Muell.	+	+	+
Kochia brevifolia R.Br.	+	+	+
K. pentagona R. H. Anderson	+	−	−
Enchylaena tomentosa R.Br.	+	+	+
Salsola kali L.	+	+	+
AMARANTHACEAE			
Alternanthera denticulata R.Br.	+	−	−
PORTULACACEAE			
Portulaca oleracea L.	+	−	+
RANUNCULACEAE			
Clematis microphylla DC.	−	+	−
LAURACEAE			
Cassytha melantha R.Br.	−	+	−
PAPAVERACEAE			
* *Papaver hybridum* L.	−	+	+
* *Fumaria micrantha* Lag.	−	+	+
CRUCIFERAE			
* *Brassica tournefortii* Gouan	−	+	+
* *Sisymbrium orientale* L.	+	+	+
* *Raphanus raphanistrum* L.	−	−	+
PITTOSPORACEAE			
Pittosporum phillyreoides DC.	−	+	+
Bursaria spinosa Cav.	−	−	+
Billardiera cymosa F. Muell.	−	+	−
LEGUMINOSAE			
Acacia acinacea Lindl.	−	+	+
A. microcarpa F. Muell.	−	+	+
A. ligulata A. Cunn. ex Benth.	+	−	+
A. hakeoides A. Cunn. ex Benth.	−	+	−
A. pycantha Benth.	−	+	+
A. lineolata Benth.	−	+	+
A. oswaldii F. Muell.	+	−	+
Cassia nemophila A. Cunn. ex Vog.	−	+	+
C. sturtii R.Br.	+	−	+
* *Medicago minima* (L.) L.	+	+	+
* *M. truncatulata* J. Gaertn. (syn. *M. tribuloides* Desr.)	+	+	+
* *M. sativa* L.	−	+	+
* *M. polymorpha* L. var. *ciliaris* (Ser.) Shinners	−	+	+
* *M. polymorpha* L. var. *polymorpha* (syn. *M. denticulata* Willd.)	+	+	+
* *M. scutellata* (L.) Mill.	−	+	−
* *M. littoralis* Rhode.	−	+	−
* *M. minima* (L.) L.	+	+	+
* *Melilotus indica* (L.) All.	−	+	+
Templetonia sulcata (Meissn.) Benth.	−	−	+
Swainsona procumbens (F. Muell.) F. Muell.	−	−	+
S. swainsonioides (Benth.) A. T. Lee	−	−	+
* *Vicia sativa* L.	−	+	−

APPENDIX 2—*continued*

	1	2	3
OXALIDACEAE			
Oxalis corniculata L.	−	+	+
O. pes-caprae L.	−	+	+
GERANIACEAE			
* *Erodium cicutarium* (L.) Ait.	+	+	+
* *E. crinitum* R. C. Carolin	+	+	+
ZYGOPHYLLACEAE			
Zygophyllum glaucum F. Muell.	−	+	+
EUPHORBIACEAE			
Euphorbia drummondii Boiss.	−	+	+
MALVACEAE			
Lavatera plebeia Sims	+	+	+
Sida corrugata Lindl.	−	+	+
MYRTACEAE			
Eucalyptus incrassata Labill.	−	+	−
E. dumosa A. Cunn. ex Schauer	−	+	+
E. oleosa F. Muell. ex Miq.	−	+	+
E. gracilis F. Muell.	−	+	−
E. calycogona Turcz.	−	+	+
E. viridis R. T. Baker	−	+	−
E. largiflorens F. Muell.	+	−	+
E. foecunda Schau.	−	+	−
E. behriana F. Muell.	−	−	+
Melaleuca uncinata R.Br.	−	+	−
M. pubescens Schauer	−	+	−
ONAGRACEAE			
Oenothera stricta Ledeb.	−	+	−
PRIMULACEAE			
* *Anagallis arvensis* L.	−	+	−
CONVOLVULACEAE			
Convolvulus erubescens Sims	+	+	+
* *C. arvensis* L.	−	+	+
BORAGINACEAE			
Halgania lavandulacea Endl.	−	+	−
Heliotropium europaeum L.	+	+	+
* *Amsinckia hispida* (Ruiz. and Pav.) Johnst.	−	+	+
* *A. lycopsoides* Lehm.	−	+	−
* *Lithospermum arvense* L.	+	+	+
LABIATAE			
* *Marrubium vulgare* L.	−	+	+
* *Lamium amplexicaule* L.	+	+	+
SOLANACEAE			
* *Lycium ferrocissinum* Miers	−	+	+
Solanum nigrum L.	+	+	+
S. simile F. Muell.	−	−	+
S. esuriale Lindl.	+	+	+
* *Datura stramonium* L.	+	−	−
MYOPORACEAE			
Myoporum platycarpum R.Br.	+	+	+
M. montanum R.Br.	−	−	+
M. deserti A. Cunn. ex Benth.	−	+	+
Eremophila longifolia (R.Br.) F. Muell.	+	−	+
PLANTAGINACEAE			
* *Plantago coronopus* L.	+	−	−
P. varia R. Br.	+	−	−
CURCURBITACEAE			
* *Cucumis myriocarpus* Naudin	+	+	+
* *Citrullus vulgaris* Schrad.	−	+	+

Appendix 2—*continued*

	1	2	3
COMPOSITAE			
Vittadinia triloba (Gaud.) DC.	+	+	+
Olearia ramulosa (Labill.) Benth.	−	+	−
Gnaphalium luteo-album L.	−	+	+
Helipterum corymbiflorum Schlechtendal	+	+	+
Helichrysum leucopsidium DC.	−	+	−
* *Inula graveolens* (L.) Desf.	+	+	+
* *Xanthium spinosum* L.	+	−	+
Senecio lautus Forst. f. ex Willd.	−	+	−
Centipeda cunninghamii (DC.) A. Br. & Aschers	+	−	−
* *Arctotheca calendula* (L.) Leyvns	−	+	−
* *Centaurea melitensis* L.	−	+	+
Microseris scapigera Forst. f. ex Sch. Bip.	+	−	−
* *Hedypnois cretica* (L.) Willd.	+	−	+
* *Hypochoeris radicata* L.	+	+	−
* *Scorzonera laciniata* L.	−	+	−
* *Picris echioides* L.	+	+	+
* *Chondrilla juncea* L.	−	+	+
* *Sonchus oleraceus* L.	+	+	+